stages, the pace of destruction soon slows and reactive new bone, both as osteophyte formation and as subchondral sclerosis, appears to limit the destruction. Special Plate Fig. 7 shows such a painful osteoarthritic hip-joint at the end of a period of rapid progression in a patient aged 67 *not* treated with steroids.

Our patients were notable, not only for the rapid destructive changes in the hip-joint, but also for their relative freedom from pain. In one of our cases (Case 3), however, severe hip pain gradually developed when oral steroid therapy was stopped. This suggests that the relief of pain produced by steroids is a significant factor, for it may well be that excessive and unguarded activity in such joints resulting from the relief of pain leads to excessive destruction—a process which in the normal way is held in check by reflex protective muscle spasm.

One patient (Case 4), and probably a second (Case 3), had normal hips before steroids were given, and in these instances it is more difficult to explain why the joints should have suffered in this manner. In Case 4 there was general osteoporosis, and similar changes may also account for the destruction of the femoral head in Case 3. It may be that the mechanism for the production of this arthropathy is a combination of loss of joint pain, osteoporosis, and trabecular stress fractures, which together produce the changes we have described. It is probably significant that very similar changes are seen in patients suffering from tabes dorsalis; indeed, the *x*-ray appearance of the hips in our first three cases is almost indistinguishable from that of a typical "Charcot's joint."

The dose of steroids required to produced destructive joint changes appears to vary greatly in those cases so far reported. It does seem that, when given by mouth, a relatively high dose is required over a prolonged period; though Case 3 is an exception to this, for severe joint disorganization occurred after only 15 weeks' administration of prednisone in a daily dose of 10 mg. Case 4, on the other hand, showed early destructive changes only after continuous oral steroid therapy in high dosage for 3½ years.

The effect of intra-articular administration is just as variable. Case 2 received only three injections into her hip, but nevertheless rapid and severe joint destruction developed. The only other patient recorded in the literature to have developed similar changes after intra-articular injection alone required 18 monthly injections before developing the typical arthropathy (Chandler *et al.*, 1959).

Conclusion

Ever since cortisone and its equivalents became freely available in Great Britain the use of corticosteroids in both hospital and general practice has increased. Clearly, therefore, it is important that the possible damaging effect upon joints should be widely known. It is only recently that such cases have been reported, but already it appears that the condition of steroid-induced joint degeneration is becoming more common. It may well be that as the number of patients receiving steroids increases we shall see more in whom arthritic, and even previously normal, hip-joints have silently crumbled away.

Careful observation of patients on long-term or high-dose steroid therapy is essential so that the early evidence of hip destruction may be detected and treatment adjusted accordingly. Before advising treatment with either oral or intra-articular administration of corticosteroids this possible complication should be borne in mind and the likelihood of accelerated joint destruction weighed against the benefit which the patient is likely to derive.

Summary

The development of relatively painless destruction of the hip-joint in four patients treated with corticosteroids is described. "Steroid arthropathy" of the hip is discussed, and the possibility of this complication developing in the arthritic, or even previously normal, hips of patients treated with corticosteroids emphasized.

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VISION, VISUAL ACUITY, AND OCULAR REFRACTION OF YOUNG MEN

FINDINGS IN A SAMPLE OF 1,033 SUBJECTS

BY

ARNOLD SORSBY,* M.D., F.R.C.S.

MICHAEL SHERIDAN, F.B.O.A.

GEORGE A. LEARY, F.S.M.C.

Courage Laboratory, Royal Eye Hospital, London

AND

B. BENJAMIN, Ph.D., F.I.A.

Among the various anthropometric surveys available on the population of this country there is none on the refraction of the eye. Several attempts have been made to establish the distribution of visual acuity, among which the survey on employees in Royal Ordnance Factories during 1943–6 (Black, 1951) was perhaps the most complete. All such studies are, however, open to the objection that they deal with selected material. As for refraction, an acceptable survey requires assessment of the static refraction, and this involves cycloplegia, complicating a fairly tedious task still more. In the present analysis we have attempted to obtain an approach to an unselected series by examining young men called up for National Service. The results recorded here may therefore be taken as nearly representative of young men of 18 to 22 years of age in the general population as could be obtained.

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Such an investigation has a practical as well as a theoretical significance. It gives, for the first time, data on the distribution of refractive errors in young men of this country, and so helps to assess the requirements for ophthalmic care in the community as a whole.

Material

The investigation was carried out on 1,056 National Service recruits at an R.A.M.C. depot. This corps has no restriction on the refractive errors of recruits, within the range which is acceptable to the Army (+8 D to −6 D). Thirty-nine records were discarded: 14 because they were incomplete, 18 because the men concerned were not Europeans, 5 because adequate cycloplegia was not achieved, and 2 because the men concerned were born before 1930. The total available for analysis was thus 1,017.

The ages of the men examined ranged between 17 and 27 years: 883 were aged 19, 20, and 21 years, 59 were 22 years, 25 were 23 years, 28 were aged 24 to 27 years, while 38 were aged 17 and 18 years. There is nothing to suggest that the age-groups 17–18 and 24–27 years differed substantially from the major age-groups.

This material was weighted by the addition of 16 cases —13 myopes and 3 hypermetropes—extracted at random from records supplied by the Ministry of Labour as a a result of a special inquiry on men rejected for National Service because of refractive errors. No allowance was made for a small group rejected because of eye disease (a group with an incidence of 0.6%).

Two considerations arise concerning the validity of this adjusted sample as representative of young male adults in the general population:

1. As it consists of men accepted for National Service, this sample must be regarded as weighted in the direction of the fitter members of the male population. There is some evidence (Rosenbaum, 1957) that recruits rejected on grounds other than vision may also have generally poorer vision than those who were not so rejected. The extent of this correlation is not precisely known, and there is no statistical basis for adjusting our material. Any sample based on Army intake is therefore probably selected in the direction of better vision.

2. In the present sample, taken from a branch of the Army with relatively low visual standards, the incidence of defective vision—vision of less than 6/6—was 24.2% of eyes and 19.4% of men—that is, higher than in the Army intake in 1952, when the corresponding figures were 20.6 and 15.5% (Report of the Health of the Army, 1955). This militates against the bias shown under paragraph 1.

It would therefore seem reasonable to assume that the sample is on balance fairly near to the young male adult population of the country.

Methods

In the case of the recruits, unaided vision was recorded, using a clean Snellen chart illuminated by a tungsten lamp which gave a mean intensity of illumination of 30 lumens per square foot. A cover test was also carried out. Two drops of cyclopentolate hydrochloride were then instilled into each eye, and the refractive error was determined by retinoscopy, with a subjective check after an interval of 30 to 90 minutes. The vertex distance was measured in each case, so that the ocular refraction could be calculated. The 16 men added to the series had also been refracted under cycloplegia, but no information was available on the conditions in which the tests were carried out, or on the vertex distance. The ocular refraction in these cases was calculated on the assumption that the vertex distance was 10 mm., since this was the value most commonly found with the recruits. The error resulting from this assumption is unlikely to exceed 2 mm., which is equivalent to an error of only 0.3 D, in the highest refractive error found.

Analysis

Vision and Visual Acuity

As can be seen from Table I, some 60% of eyes and around 70% of young men have unaided vision of 6/6 or better, while vision only slightly below this (6/7.5) is found in another 12 to 15%. In the general population over 80% of young men may be regarded as having full vision, unaided by glasses. Some 16% have vision within the range of 6/9 to 6/36, while less than 4% have vision of 6/60 or less. Table I also shows that, as against some 20% of young men with subnormal vision, visual acuity—that is, vision aided by glasses—was subnormal in only 3% if 6/7.5 or better is taken as normal. Only 0.4% of the young adult male population have corrected visual acuity of 6/18 or less; the corresponding percentage for eyes is 2.6.

TABLE I.—*Percentage Distribution of Unaided Vision and of Corrected Visual Acuity in Men Aged 17-27 Years*

Degree of Vision or Visual Acuity	2,066 Eyes		1,033 Men (by the Better Eye)	
	Unaided Vision	Visual Acuity with Best Correction	Unaided Vision	Visual Acuity with Best Correction
6/6 and better ..	61·0	82·5	67·7	88·9
6/7·5	14·8	10·4	12·9	8·1
6/9	7·1	3·3	6·2	1·9
6/12	3·6	1·2	3·2	0·7
6/18	3·0	1·1	2·6	0·3
6/24	2·9	0·5	1·9	0·1
6/36	3·1	0·5	2·3	0·0
4/60 to 6/60 ..	1·9	0·3	1·5	0·0
3/60 and less ..	2·6	0·2	1·7	0·0
Total ..	100·0	100·0	100·0	100·0

Range of Refraction

In this series the refraction (assessed by the mean spherical value where the two meridians did not differ by more than 0.5 D, and by the lower meridian in eyes with astigmatism in excess of 0.5 D) extended over the range of +10 to −13 D. As can be seen from Table II, the extreme refractions were exceptional. A proportion of the order of 75% of eyes—and of men—showed ocular refractions between 0 and +2 D. Hypermetropia between 2 and 4 D accounts for some 10%, while the higher degrees of hypermetropia were responsible for a further 4%. The different degrees of myopia contributed the remainder of about 11%, but only less than 2% of the total was contributed by myopes of over 4 D.

Several points are noteworthy: (1) There was little difference in the distribution of the different refractions assessed by eyes or by individuals. (2) Some 90% of this population has a range of refraction between −1 and +4 D. The remaining 10% are fairly equally divided between myopes between −1 and −13 D and hypermetropia between +4 and +10 D. (3) There is nothing to suggest any myopic excess. The distribution is asymmetrical, as is shown by curve (A) in the Chart. The peak is between 0 and +1 D. Near the centre of the distribution the descent is more gradual on the hypermetropic side. Whilst a few extreme cases of myopia do extend the tail of the distribution on the myopic side, within a shorter range of refraction hypermetropia predominates.

Table II also shows the distributions obtained when the material was considered as two distinct groups—one showing spherical refractions only—that is, any astigmatism present was 0.5 D or less—and the other showing astigmatic error—that is, the eyes all had astigmatism of 0.6 D or more, with or without a spherical error. The first of these groups, which contained some 80% of all cases, showed essentially the same distribution as the material as a whole (Chart, curve B). The astigmatic 20% or so showed a distinctly different pattern (Table II and Chart, curve C); only some 40% of all cases now fell in the category of 0 to +2 D, suggesting that astigmatism tends to be distributed more evenly over the whole range of refractions. This is discussed more fully below. The discontinuous curves in the Chart are shown to indicate departure from normal distribution.

TABLE II.—*Percentage Distribution of Ocular Refraction* in 2,066 Eyes and 1,033 Men Aged 17–27 Years (Classified by the Better Eye†)*

Ocular Refraction (D)	Series as a Whole		Series Subdivided to Show:			
			Mainly Spherical Errors		Astigmatism 0·6 D or More With or Without Spherical Error	
	2,066 Eyes	1,033 Persons	1,680 Eyes	878 Persons	386 Eyes	155 Persons
+9·0 to +9·9	0·1				0·3	
+8·0 „ +8·9	0·2	0·2	0·1	0·1	0·5	0·6
+7·0 „ +7·9	0·4	0·3	0·1	0·0	1·6	2·0
+6·0 „ +6·9	0·9	0·6	0·2	0·1	3·6	3·2
+5·0 „ +5·9	1·2	1·2	0·1	0·1	5·7	7·8
+4·0 „ +4·9	1·7	1·8	0·9	0·8	5·4	7·1
+3·0 „ +3·9	4·0	3·1	2·7	2·3	9·9	7·8
+2·0 „ +2·9	6·4	6·4	5·9	5·9	8·3	9·0
+1·0 „ +1·9	33·4	30 9	37·5	33·5	15·8	16·1
0·0 „ +0·9	40·0	44·8	43·0	47·8	26·9	27·8
−0·1 „ −1·0	5·1	5·1	4·3	4·6	8·6	8·4
−1·1 „ −2·0	2·4	1·9	2·0	1·8	3·9	2·6
−2·1 „ −3·0	1·5	1·2	1·1	1·0	3·6	2·6
−3·1 „ −4·0	0·9	0·9	0·9	0·9	1·0	0·6
−4·1 „ −5·0	0·4	0·3	0·4	0·4	0·5	0·0
−5·1 „ −6·0	0·4	0·5	0·1	0·1	2·1	2·6
−6·1 „ −7·0	0·4	0·4	0·3	0·4	1·0	0·6
−7·1 „ −8·0	0·2	0·2	0·1	0·1	0·5	0·6
−8·1 „ −9·0	0·1	0·1	0·1	0·1	0·0	0·0
−9·1 „ −10·0	0·2	0·1	0·1		0·8	0·6
−10·1 „ −11·0	0·0		0·0			
−11·1 „ −12·0	0·0		0·0			
−12·1 „ −13·0	0·1		0·1			
Total ..	100·0	100·0	100·0	100·0	100·0	100·0

* The mean spherical refraction (sphere + ½ cylinder) is used for the mainly spherical eyes, and the ocular refraction in the least ametropic meridian for eyes with astigmatism of >0·5 D.

† The better eye was taken as the eye with the better vision or, where vision was equal in the two eyes, the eye with the more emmetropic refraction.

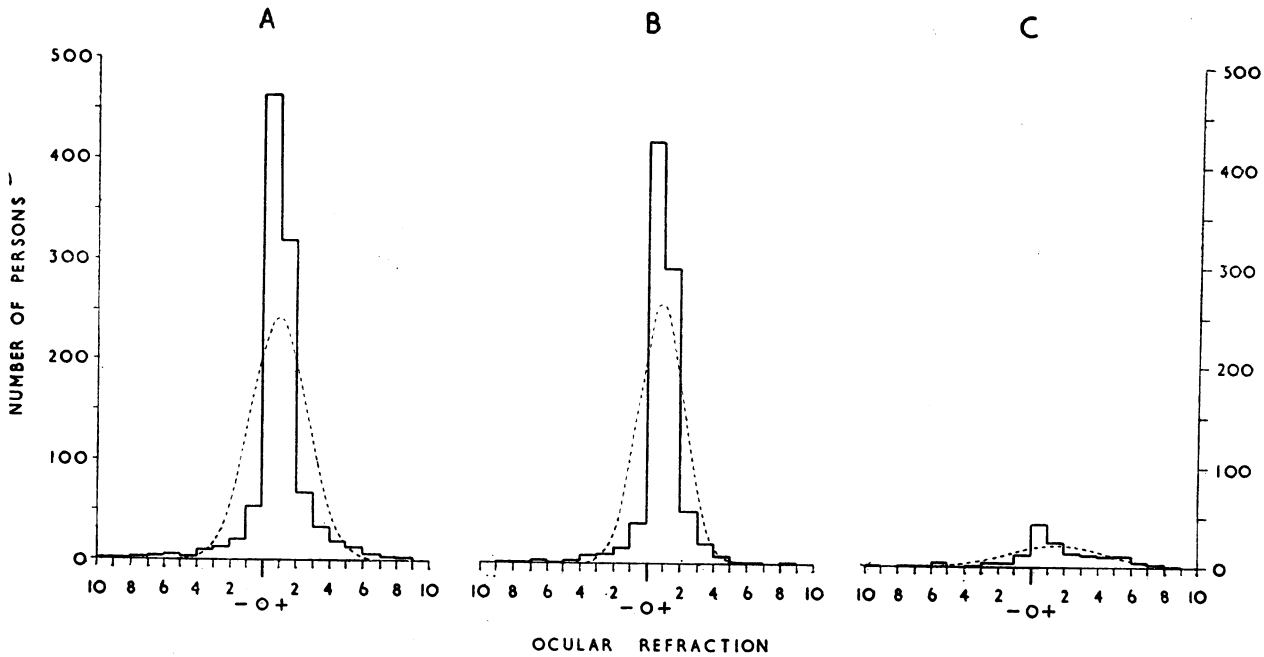
Distribution of the Different Degrees of Astigmatism

Actual Distribution.—Table III shows that some degree of astigmatism is present in about 60% of cases. As is already known from Table II, rather less than 20% have astigmatism in excess of 0.5 D. Nearly half of this proportion is confined to the relatively low degree of 0.6 to 1 D: 5% of eyes have astigmatism of 1.1 to 2 D, 2.5% astigmatism of 2.1 to 3 D, and a further 2.3% have astigmatism in excess of this. In all, some 10% of eyes—and rather fewer individuals—have astigmatism in excess of 1 D.

TABLE III.—*Percentage Distribution of Astigmatism in Men Aged 17–27 Years*

Degree of Astigmatism (D)	In 2,066 Eyes	In 1,033 Men (by Better Eye)
0·0 or less than 0·2	38·6	44·4
0·2 to 0·3	26·3	25·9
0·4 „ 0·5	16·4	14·6
0·6 „ 1·0	8·9	7·6
1·1 „ 2·0	5·0	4·3
2·1 „ 3·0	2·5	1·8
3·1 „ 4·0	1·2	0·9
4 1 „ 5·0	0·7	0·3
5·1 „ 6·0	0·3	0·2
6·1 „ 7·0	0·1	0·0
	100·0%	100·0%

In Relation to the Spherical Refraction.—It can be seen from Table IV that the 46 cases of astigmatism in excess of 3 D, follow the same distribution as the lower degrees of astigmatism—that is, they tend to be concentrated around the central spherical values and are not associated with the extreme refractions. Nevertheless astigmatism is proportionately more frequent among those with spherical error than in those with



Curves of distribution of refractive states in 1,033 men, classified by the better eye. A, All refractions. B, Spherical refractions (i.e., with astigmatism of 0 to 0.5 D). C, Astigmatic errors (i.e., astigmatism of 0.6 D or more with or without a spherical error.

TABLE IV.—*Astigmatism of 0.6 D or More in Relation to Spherical Refraction*

Degree of Astigmatism (D)	Refraction in Least Ametropic Meridian (D)																				Total
	−9·1 to −10·0	−8·1 „ −9·0	−7·1 „ −8·0	−6·1 „ −7·0	−5·1 „ −6·0	−4·1 „ −5·0	−3·1 „ −4·0	−2·1 „ −3·0	−1·1 „ −2·0	−0·1 „ −1·0	0·0 „ +0·9	+1·0 „ +1·9	+2·0 „ +2·9	+3·0 „ +3·9	+4·0 „ +4·9	+5·0 „ +5·9	+6·0 „ +6·9	+7·0 „ +7·9	+8·0 „ +8·9	+9·0 „ +9·9	
0·6 to 1·0 ..				1	4	1	0	6	6	17	66	28	7	15	5	16	6	6	0	1	185
1·1 „ 2·0 ..	1	0	1	2	4	1	2	2	4	7	12	20	9	17	10	6	5				103
2·1 „ 3·0 ..	2	0	1	1	0	0	1	1	4	5	12	7	7	1	5	1	2	0	2		52
3·1 „ 4·0 ..							1	1	1	2	7	3	4	5							24
4·1 „ 5·0 ..								1	0	0	7	3	2	1							14
5·1 „ 6·0 ..								2	0	2	0	0	3								7
6·1 „ 7·0 ..								1													1
Totals ..	3	0	2	4	8	2	4	14	15	33	104	61	32	39	20	23	13	6	2	1	386

emmetropia in the lower meridian—i.e., the astigmatic eye is rather more likely to have poorly correlated optical components.

Incidence of Squint and of Amblyopia ex Anopsia

Table V shows that this group of 1,033 men contained 41 with squint—34 convergent and 7 divergent. Two further points emerge. (1) Of the total of 34 convergent

TABLE V.—*Incidence of Squint in 1,033 Men*

Type of Squint	1,033 Men		789 Men with Mainly Spherical Refractions		244 Men with Astigmatism of 0·60 or More in One or Both Eyes	
	No.	%	No.	%	No.	%
Convergent ..	34	3·3	12	1·5	22	9·0
Divergent ..	7	0·7	2	0·3	5	2·0
Total ..	41	4·0	14	1 8	27	11·0

squints, 22 were seen in the relatively small group of men with astigmatism in excess of 0.5 D in one or both eyes. The actual incidence of convergent squint in men with spherical errors was 1.5%, while the incidence in men with astigmatism—as defined—was 9%. (2) The squint was of the alternating type in 9 out of the 34 cases of convergent squint (Table VI); in these alter-

TABLE VI.—*Degree of Amblyopia in the Squinting Eye*

Corrected Visual Acuity in Squinting Eye	Type of Squint			
	Convergent		Divergent	
	Unilateral	Alternating	Unilateral	Alternating
6/6 or better ..	1	6	2	1
6/7·5	3	2	1	
6/9	6	1	1	
6/12	4		0	
6/18	4		1	
6/24	2		1	
6/36	2			
6/60	0			
<6/60	3			
Totals ..	25	9	6	1

nating cases there was no tangible amblyopia. Of the remaining 25 cases, no fewer than 15 had visual acuity of 6/12 or less in the squinting eye, severe amblyopia (6/36 and less) being present in five.

In this group of 1,033 men the total incidence of squint was therefore 4.0% and the incidence of severe amblyopia ex anopsia (6/36 or less) 0.5%.

Discussion

1. *Refraction Curves.*—Steiger (1913), who at the beginning of the century showed that corneal power was distributed over a fairly wide range extending between 38 to 50 D in 5,000 eyes in children, concluded that the distribution followed a Normal curve, and postulated that other components of refraction also showed the same type of distribution and that ocular refraction represented the free association of these components. When refraction curves began to be constructed it became clear that this simple view was not tenable. Thus Gallus (1924) held that only values extending between −9 and +9 could be explained on a random combination of the optical elements of the eye, while Wibaut (1926) stressed the excess of emmetropic refractions. Scheerer (1928) and Betsch (1929) emphasized the excess of high myopes and held that it would be necessary to exclude eyes with conus formation to obtain a normal distribution of refraction material. Various other curves have been published stressing one or other point, but all these curves suffered from the drawback that they are hardly representative of unselected populations. Frequently they are material collected at hospitals or in the consulting room, and, as such, would of necessity be influenced by abnormal findings.

Even when care is taken—as some observers have done—to exclude refraction cases, there is always a possibility that a refractive anomaly might have contributed to the pathological condition for which the patient was examined. A none too critical analysis of this literature leaves very little that can be accepted without qualification, the most acceptable being the curve on Palenegrids established upon a primitive African group by Holm (1937), the curve for Eskimos established by Skeller (1954), and the curve for recruits in Sweden established by Strömberg (1936). It is of interest that these three curves, while they bring out clearly the marked excess (above Normal expectation) of emmetropic and near emmetropic eyes, give no more support than our study for the widely held view that there is a marked excess of myopes. It would, however, seem that in any population higher degrees of myopia than of hypermetropia occur, but, numerically, such highly myopic eyes are too few to produce any substantial skewness in a curve, and, moreover, the marked degrees of myopia in previous studies are to some extent illusory, as the ocular refraction is much less than the spectacle refraction in these high myopes.

The present curve follows closely the same pattern as shown by Holm and by Skeller in non-European races and by Strömberg for young men in Sweden. In our series, refractions in excess of +4 D were present in 4%, and refractions in excess of −4 D in only 2%—against a similar incidence of myopes and a rather lower

incidence of hypermetropes in Strömberg's series. It would seem that the one substantial problem thrown up by representative refraction curves is the nature of the excess of emmetropic and near emmetropic eyes over Normal expectation. On this issue it is relevant to stress the fact that eyes with an ocular refraction in excess of ±4 D fall outside the range of eyes with components that are observed in the emmetropic eye, and as such may perhaps be regarded as malformations of a pathological character (Sorsby, Benjamin, Davey, Sheridan, and Tanner, 1957).

2. *Astigmatic Errors.*—Astigmatic errors in excess of 1 D occur in 10% of our sample, while astigmatism between 0.5 and 1 D was seen in somewhat less than 10%. Since there is no correlation between the spherical errors and astigmatic errors, other than a general tendency for astigmatism to be associated with some spherical error, there is the possibility that these astigmatic errors represent an inherited tendency—a corneal defect inherited independently of the spherical refraction of the eye. This cannot be decided on the available material.

3. *Age and Sex in Relation to the Refraction Curve.*—There is no doubt that the refraction curve in children differs from that of adults, if only because so many more hypermetropic eyes are met with in childhood. The available material is confined to the collected and heterogeneous data given by Wibaut (1926) on the newborn infant, and the small series on Jewish and Gentile children in London recorded by Sorsby (1935). Fuller studies are needed if only to determine what is to be regarded as normal at the different periods of school life. As for refraction curves in women, none seem to have been established—all the more regrettable as it is widely held that refractive errors occur more often in women. The difficulties in establishing a curve free from selection are very real.

4. *Squint and amblyopia ex anopsia.*—The small series of cases recorded here suggest that one person in every 200 loses useful vision in one eye from squint. The question is whether the present sample gives a true indication of the distribution of squint and amblyopia in the population.

5. *Nature of the Refraction Curves.*—The broken lines in the Chart represent attempts to fit Normal curves to the distribution and show clearly that the distributions are more sharply peaked than the Normal curve and are skew. As compared with the distribution expected on the basis of the Normal curve there is a large excess of persons with near emmetropic eyes. Several attempts were made to fit mathematical curves to the distribution, but the shape was too distorted by long tails to give results of any practical value.

6. *Some Practical Aspects.*—It can be seen from Table II that hypermetropia of 4 D and more and myopia of −1 D and more (with or without any astigmatism) affect 11.1% of all eyes. The need for optical care in these cases is unquestionable. To this group must be added the 136 eyes shown in Table IV as possessing astigmatism in excess of 1 D—unassociated with a spherical refraction as defined above—that would of itself call for correction, giving an additional 6.6% calling for attention. In all, the lowest estimate of eyes needing optical correction is therefore 17.7%. In terms of persons this percentage would be rather less, as some men would have one good eye and no symptoms calling for glasses. On the other hand, some men with refractive errors lower than those considered here would need glasses. It may therefore be taken that at least 15% would require glasses, and the percentage might possibly be twice this, seeing that 10.4% of eyes show hypermetropia of 2 to 4 D and 5.1% myopia of 0.1 to 1 D.

Summary

A sample consisting of 1,033 young men called up for National Service showed that some 60% of eyes and 70% of young men have unaided vision of 6/6 or better, while vision only slightly below this, 6/7.5, is found in another 12 to 15%. In the general population over 80% of young men can therefore be regarded as having full vision unaided by glasses. Only 4% have unaided vision of 6/60 or less. With correction the incidence of vision of less than 6/7.5 is 3%; only 0.4% of young men have corrected visual acuity of 6/18 or less.

The range of ocular refraction in this series extended between +10 D and −13 D. Some 75% of eyes and of men showed refraction between 0 and +2 D; some 9% showed myopia of up to 4 D, and 2% myopia in excess of this. In all, some 90% of the population have a range of refraction between −1 D and +4 D.

Nearly 20% of the population has astigmatism in excess of 0.5 D, fairly evenly divided between astigmatism of 0.6–1 D and astigmatism in excess of 1 D. The higher degrees of astigmatism were not yoked to the higher degrees of spherical errors, but were proportionately distributed over the whole range of refractions.

Some 4% of the population showed squint, and 0.5% showed amblyopia ex anopsia of a severe type (6/36 or less).

The curve of distribution of ocular refraction gives little support for the widely held view that there is an excess of myopia as distinct from an elongation of the myopic tail. Judged against a Normal distribution, there is a marked excess of emmetropic and near-emmetropic eyes—an excess that eliminates the belief that the individual components of refraction vary freely. The eye is obviously a correlated organ.

On the available data at least 15% and possibly as much as 25–30% of men require optical attention during early adult life.

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